

D_s^\pm
was F^\pm

$$I(J^P) = 0(0^-)$$

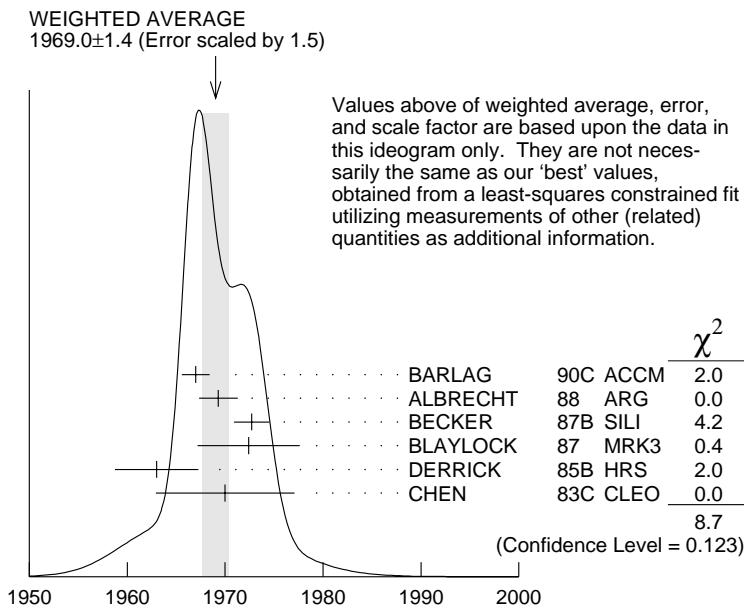
The angular distributions of the decays of the ϕ and $\bar{K}^*(892)^0$ in the $\phi\pi^+$ and $K^+\bar{K}^*(892)^0$ modes strongly indicate that the spin is zero. The parity given is that expected of a $c\bar{s}$ ground state.

D_s^\pm MASS

The fit includes D^\pm , D^0 , D_s^\pm , $D^{*\pm}$, D^{*0} , and $D_s^{*\pm}$ mass and mass difference measurements. Measurements of the D_s^\pm mass with an error greater than 10 MeV are omitted from the fit and average. A number of early measurements have been omitted altogether.

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
1968.6 ± 0.6 OUR NEW UNCHECKED FIT		Error includes scale factor of 1.1. [1968.5 ± 0.6 MeV OUR 1998 FIT Scale factor = 1.1]		
1969.0 ± 1.4 OUR AVERAGE		Error includes scale factor of 1.5. See the ideogram below.		
1967.0 ± 1.0 ± 1.0	54	BARLAG	90C ACCM	π^- Cu 230 GeV
1969.3 ± 1.4 ± 1.4		ALBRECHT	88 ARG	e^+e^- 9.4–10.6 GeV
1972.7 ± 1.5 ± 1.0	21	BECKER	87B SILI	200 GeV π, K, p
1972.4 ± 3.7 ± 3.7	27	BLAYLOCK	87 MRK3	e^+e^- 4.14 GeV
1963 ± 3 ± 3	30	DERRICK	85B HRS	e^+e^- 29 GeV
1970 ± 5 ± 5	104	CHEN	83C CLEO	e^+e^- 10.5 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1968.3 ± 0.7 ± 0.7	290	¹ ANJOS	88 E691	Photoproduction
1980 ± 15	6	USHIDA	86 EMUL	ν wideband
1973.6 ± 2.6 ± 3.0	163	ALBRECHT	85D ARG	e^+e^- 10 GeV
1948 ± 28 ± 10	65	AIHARA	84D TPC	e^+e^- 29 GeV
1975 ± 9 ± 10	49	ALTHOFF	84 TASS	e^+e^- 14–25 GeV
1975 ± 4	3	BAILEY	84 ACCM	hadron ⁺ Be → $\phi\pi^+X$

¹ ANJOS 88 enters the fit via $m_{D_s^\pm} - m_{D^\pm}$ (see below).



D_s^\pm mass (MeV)

$$m_{D_s^\pm} - m_{D^\pm}$$

The fit includes D^\pm , D^0 , D_s^\pm , $D^{*\pm}$, D^{*0} , and $D_s^{*\pm}$ mass and mass difference measurements.

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
99.2\pm0.5 OUR FIT		Error includes scale factor of 1.1.		
99.2\pm0.5 OUR AVERAGE				
99.5 \pm 0.6 \pm 0.3		BROWN	94 CLE2	$e^+ e^- \approx \gamma(4S)$
98.5 \pm 1.5	555	CHEN	89 CLEO	$e^+ e^-$ 10.5 GeV
99.0 \pm 0.8	290	ANJOS	88 E691	Photoproduction

D_s^\pm MEAN LIFE

Measurements with an error greater than 0.2×10^{-12} s or with fewer than 100 events are omitted from the average.

VALUE (10^{-12} s)	EVTS	DOCUMENT ID	TECN	COMMENT
0.496$^{+0.010}_{-0.009}$ OUR NEW AVERAGE		$[(0.467 \pm 0.017) \times 10^{-12}$ s OUR 1998 AVERAGE]		
0.518 \pm 0.014 \pm 0.007	1662	AITALA	99 E791	π^- nucleus, 500 GeV

0.4863 ± 0.0150	$+0.0049$	-0.0051	2167	² BONVICINI	99	CLE2	$e^+ e^- \approx \gamma(4S)$	
0.475	± 0.020	± 0.007	900	FRAZETTI	93F	E687	$\gamma Be, D_s^+ \rightarrow \phi\pi^+$	
0.50	± 0.06	± 0.03	104	FRAZETTI	90	E687	$\gamma Be, \phi\pi^+$	
0.56	$+0.13$	-0.12	144	ALBRECHT	88I	ARG	$e^+ e^- 10 \text{ GeV}$	
0.47	± 0.04	± 0.02	228	RAAB	88	E691	Photoproduction	
• • • We do not use the following data for averages, fits, limits, etc. • • •								
0.33	$+0.12$	-0.08	± 0.03	15	ALVAREZ	90	NA14	$\gamma, D_s^+ \rightarrow \phi\pi^+$
0.469	$+0.102$	-0.086		54	³ BARLAG	90C	ACCM	$\pi^- Cu 230 \text{ GeV}$
0.31	$+0.24$	-0.20	± 0.05	18	AVERILL	89	HRS	$e^+ e^- 29 \text{ GeV}$
0.48	$+0.06$	-0.05	± 0.02	99	ANJOS	87B	E691	See RAAB 88
0.33	$+0.10$	-0.06		21	⁴ BECKER	87B	SILI	$200 \text{ GeV } \pi, K, p$
0.57	$+0.36$	-0.26	± 0.09	9	BRAUNSCH...	87	TASS	$e^+ e^- 35-44 \text{ GeV}$
0.47	± 0.22	± 0.05		141	CSORNA	87	CLEO	$e^+ e^- 10 \text{ GeV}$
0.35	$+0.24$	-0.18	± 0.09	17	JUNG	86	HRS	See AVERILL 89
0.26	$+0.16$	-0.09		6	USHIDA	86	EMUL	ν wideband
0.32	$+0.30$	-0.13		3	BAILEY	84	ACCM	$\text{hadron}^+ Be \rightarrow \phi\pi^+ X$
0.19	$+0.13$	-0.07		4	USHIDA	83	EMUL	See USHIDA 86

² BONVICINI 99 obtains 1.19 ± 0.04 for the ratio of D_s^+ to D^0 lifetimes.

³ BARLAG 90C estimates the systematic error to be negligible.

⁴ BECKER 87B estimates the systematic error to be negligible.

D_s^+ DECAY MODES

Branching fractions for modes with a resonance in the final state include all the decay modes of the resonance. D_s^- modes are charge conjugates of the modes below.

Mode	Fraction (Γ_i/Γ)	Scale factor/ Confidence level
Inclusive modes		
Γ_1 K^- anything	(13 ± 14) %	
Γ_2 \bar{K}^0 anything + K^0 anything	(39 ± 28) %	
Γ_3 K^+ anything	(20 ± 18) %	
Γ_4 non- $K\bar{K}$ anything	(64 ± 17) %	
Γ_5 e^+ anything	(8 ± 6) %	
Γ_6 ϕ anything	(18 ± 15) %	

Leptonic and semileptonic modes

Γ_7	$\mu^+ \nu_\mu$	$(4.6 \pm 1.9) \times 10^{-3}$	S=1.3
Γ_8	$\tau^+ \nu_\tau$	$(7 \pm 4) \%$	
Γ_9	$\phi \ell^+ \nu_\ell$	[a] $(2.0 \pm 0.5) \%$	
Γ_{10}	$\eta \ell^+ \nu_\ell + \eta'(958) \ell^+ \nu_\ell$	[a] $(3.5 \pm 1.0) \%$	
Γ_{11}	$\eta \ell^+ \nu_\ell$	$(2.6 \pm 0.7) \%$	
Γ_{12}	$\eta'(958) \ell^+ \nu_\ell$	$(8.9 \pm 3.4) \times 10^{-3}$	

Hadronic modes with a $K\bar{K}$ pair (including from a ϕ)

Γ_{13}	$K^+ \bar{K}^0$	$(3.6 \pm 1.1) \%$	
Γ_{14}	$K^+ K^- \pi^+$	[b] $(4.4 \pm 1.2) \%$	S=1.1
Γ_{15}	$\phi \pi^+$	[c] $(3.6 \pm 0.9) \%$	
Γ_{16}	$K^+ \bar{K}^*(892)^0$	[c] $(3.3 \pm 0.9) \%$	
Γ_{17}	$f_0(980) \pi^+$	[c] $(1.8 \pm 0.8) \%$	S=1.3
Γ_{18}	$K^+ \bar{K}_0^*(1430)^0$	[c] $(7 \pm 4) \times 10^{-3}$	
Γ_{19}	$f_0(1710) \pi^+ \rightarrow K^+ K^- \pi^+$	[d] $(1.5 \pm 1.9) \times 10^{-3}$	
Γ_{20}	$K^+ K^- \pi^+$ nonresonant	$(9 \pm 4) \times 10^{-3}$	
Γ_{21}	$K^0 \bar{K}^0 \pi^+$	—	
Γ_{22}	$K^*(892)^+ \bar{K}^0$	[c] $(4.3 \pm 1.4) \%$	
Γ_{23}	$K^+ K^- \pi^+ \pi^0$	—	
Γ_{24}	$\phi \pi^+ \pi^0$	[c] $(9 \pm 5) \%$	
Γ_{25}	$\phi \rho^+$	[c] $(6.7 \pm 2.3) \%$	
Γ_{26}	$\phi \pi^+ \pi^0$ 3-body	[c] $< 2.6 \%$	CL=90%
Γ_{27}	$K^+ K^- \pi^+ \pi^0$ non- ϕ	$< 9 \%$	CL=90%
Γ_{28}	$K^+ \bar{K}^0 \pi^+ \pi^-$	$< 2.8 \%$	CL=90%
Γ_{29}	$K^0 K^- \pi^+ \pi^+$	$(4.3 \pm 1.5) \%$	
Γ_{30}	$K^*(892)^+ \bar{K}^*(892)^0$	[c] $(5.8 \pm 2.5) \%$	
Γ_{31}	$K^0 K^- \pi^+ \pi^+$ non- $K^{*+} \bar{K}^{*0}$	$< 2.9 \%$	CL=90%
Γ_{32}	$K^+ K^- \pi^+ \pi^+ \pi^-$	$(8.3 \pm 3.3) \times 10^{-3}$	
Γ_{33}	$\phi \pi^+ \pi^+ \pi^-$	[c] $(1.18 \pm 0.35) \%$	
Γ_{34}	$K^+ K^- \pi^+ \pi^+ \pi^-$ non- ϕ	$(3.0 \pm 3.0) \times 10^{-3}$	

Hadronic modes without K 's

Γ_{35}	$\pi^+ \pi^+ \pi^-$	$(1.0 \pm 0.4) \%$	S=1.2
Γ_{36}	$\rho^0 \pi^+$	$< 8 \times 10^{-4}$	CL=90%
Γ_{37}	$f_0(980) \pi^+$	[c] $(1.8 \pm 0.8) \%$	S=1.7
Γ_{38}	$f_2(1270) \pi^+$	[c] $(2.3 \pm 1.3) \times 10^{-3}$	
Γ_{39}	$f_0(1500) \pi^+ \rightarrow \pi^+ \pi^- \pi^+$	[e] $(2.8 \pm 1.6) \times 10^{-3}$	
Γ_{40}	$\pi^+ \pi^+ \pi^- \pi^0$ nonresonant	$< 2.8 \times 10^{-3}$	CL=90%
Γ_{41}	$\pi^+ \pi^+ \pi^- \pi^0$	$< 12 \%$	CL=90%
Γ_{42}	$\eta \pi^+$	[c] $(1.7 \pm 0.5) \%$	
Γ_{43}	$\omega \pi^+$	[c] $(2.8 \pm 1.1) \times 10^{-3}$	

Γ_{44}	$\pi^+ \pi^+ \pi^+ \pi^- \pi^-$	$(6.9 \pm 3.0) \times 10^{-3}$	
Γ_{45}	$\pi^+ \pi^+ \pi^- \pi^0 \pi^0$	—	
Γ_{46}	$\eta \rho^+$	[c] $(10.8 \pm 3.1) \%$	
Γ_{47}	$\eta \pi^+ \pi^0$ 3-body	[c] < 4 %	CL=90%
Γ_{48}	$\pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^0$	$(4.9 \pm 3.2) \%$	
Γ_{49}	$\eta'(958) \pi^+$	[c] $(3.9 \pm 1.0) \%$	
Γ_{50}	$\pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^0 \pi^0$	—	
Γ_{51}	$\eta'(958) \rho^+$	[c] $(10.1 \pm 2.8) \%$	
Γ_{52}	$\eta'(958) \pi^+ \pi^0$ 3-body	[c] < 1.4 %	CL=90%

Modes with one or three K 's

Γ_{53}	$K^0 \pi^+$	$< 8 \times 10^{-3}$	CL=90%
Γ_{54}	$K^+ \pi^+ \pi^-$	$(1.0 \pm 0.4) \%$	
Γ_{55}	$K^+ \rho^0$	$< 2.9 \times 10^{-3}$	CL=90%
Γ_{56}	$K^*(892)^0 \pi^+$	[c] $(6.5 \pm 2.8) \times 10^{-3}$	
Γ_{57}	$K^+ K^+ K^-$	$< 6 \times 10^{-4}$	CL=90%
Γ_{58}	ϕK^+	[c] $< 5 \times 10^{-4}$	CL=90%

$\Delta C = 1$ weak neutral current ($C1$) modes, or Lepton number (L) violating modes

Γ_{59}	$\pi^+ e^+ e^-$	[f] $< 2.7 \times 10^{-4}$	CL=90%
Γ_{60}	$\pi^+ \mu^+ \mu^-$	[f] $< 1.4 \times 10^{-4}$	CL=90%
Γ_{61}	$K^+ e^+ e^-$	$C1 < 1.6 \times 10^{-3}$	CL=90%
Γ_{62}	$K^+ \mu^+ \mu^-$	$C1 < 1.4 \times 10^{-4}$	CL=90%
Γ_{63}	$K^*(892)^+ \mu^+ \mu^-$	$C1 < 1.4 \times 10^{-3}$	CL=90%
Γ_{64}	$\pi^+ e^\pm \mu^\mp$	$LF [g] < 6.1 \times 10^{-4}$	CL=90%
Γ_{65}	$K^+ e^\pm \mu^\mp$	$LF [g] < 6.3 \times 10^{-4}$	CL=90%
Γ_{66}	$\pi^- e^+ e^+$	$L < 6.9 \times 10^{-4}$	CL=90%
Γ_{67}	$\pi^- \mu^+ \mu^+$	$L < 8.2 \times 10^{-5}$	CL=90%
Γ_{68}	$\pi^- e^+ \mu^+$	$L < 7.3 \times 10^{-4}$	CL=90%
Γ_{69}	$K^- e^+ e^+$	$L < 6.3 \times 10^{-4}$	CL=90%
Γ_{70}	$K^- \mu^+ \mu^+$	$L < 1.8 \times 10^{-4}$	CL=90%
Γ_{71}	$K^- e^+ \mu^+$	$L < 6.8 \times 10^{-4}$	CL=90%
Γ_{72}	$K^*(892)^- \mu^+ \mu^+$	$L < 1.4 \times 10^{-3}$	CL=90%

Γ_{73} A dummy mode used by the fit. $(80 \pm 5) \%$

[a] For now, we average together measurements of the $X e^+ \nu_e$ and $X \mu^+ \nu_\mu$ branching fractions. This is the *average*, not the *sum*.

[b] The branching fraction for this mode may differ from the sum of the submodes that contribute to it, due to interference effects. See the relevant papers.

[c] This branching fraction includes all the decay modes of the final-state resonance.

- [d] This value includes only $K^+ K^-$ decays of the $f_0(1710)$, because branching fractions of this resonance are not known.
 - [e] This value includes only $\pi^+ \pi^-$ decays of the $f_0(1500)$, because branching fractions of this resonance are not known.
 - [f] This mode is not a useful test for a $\Delta C=1$ weak neutral current because both quarks must change flavor in this decay.
 - [g] The value is for the sum of the charge states or particle/antiparticle states indicated.
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CONSTRAINED FIT INFORMATION

An overall fit to 15 branching ratios uses 24 measurements and one constraint to determine 10 parameters. The overall fit has a $\chi^2 = 17.5$ for 15 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients $\langle \delta x_i \delta x_j \rangle / (\delta x_i \cdot \delta x_j)$, in percent, from the fit to the branching fractions, $x_i \equiv \Gamma_i / \Gamma_{\text{total}}$. The fit constrains the x_i whose labels appear in this array to sum to one.

x_9	58							
x_{11}	50	86						
x_{12}	38	65	56					
x_{14}	52	85	73	55				
x_{15}	57	93	79	60	92			
x_{16}	53	86	74	56	92	93		
x_{35}	47	76	65	50	84	82	81	
x_{37}	30	48	42	32	51	52	50	54
x_{73}	-59	-93	-84	-64	-95	-96	-94	-86
	x_7	x_9	x_{11}	x_{12}	x_{14}	x_{15}	x_{16}	x_{35}
								x_{37}

D_s^+ BRANCHING RATIOS

A few older, now obsolete results have been omitted. They may be found in earlier editions.

— Inclusive modes —

$\Gamma(K^- \text{ anything}) / \Gamma_{\text{total}}$	Γ_1 / Γ		
VALUE	DOCUMENT ID	TECN	COMMENT
$0.13^{+0.14}_{-0.12} \pm 0.02$	COFFMAN	91	MRK3 $e^+ e^-$ 4.14 GeV

$[\Gamma(\bar{K}^0 \text{ anything}) + \Gamma(K^0 \text{ anything})] / \Gamma_{\text{total}}$	Γ_2 / Γ		
VALUE	DOCUMENT ID	TECN	COMMENT
$0.39^{+0.28}_{-0.27} \pm 0.04$	COFFMAN	91	MRK3 $e^+ e^-$ 4.14 GeV

$\Gamma(K^+ \text{anything})/\Gamma_{\text{total}}$

VALUE	DOCUMENT ID	TECN	COMMENT
$0.20^{+0.18}_{-0.13} \pm 0.04$	COFFMAN 91	MRK3	$e^+ e^-$ 4.14 GeV

Γ_3/Γ

$\Gamma(\text{non-}K\bar{K}\text{anything})/\Gamma_{\text{total}}$

VALUE	DOCUMENT ID	TECN	COMMENT
$0.64 \pm 0.17 \pm 0.03$	5 COFFMAN	91	MRK3 $e^+ e^-$ 4.14 GeV

Γ_4/Γ

⁵ COFFMAN 91 uses the direct measurements of the kaon content to determine this non- $K\bar{K}$ fraction. This number implies that a large fraction of D_s^+ decays involve η , η' , and/or non-spectator decays.

$\Gamma(e^+ \text{anything})/\Gamma_{\text{total}}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$0.077^{+0.057+0.024}_{-0.043-0.021}$		BAI	97 BES	$e^+ e^- \rightarrow D_s^+ D_s^-$

• • • We do not use the following data for averages, fits, limits, etc. • • •

<0.20	90	6 BAI	90 MRK3	$e^+ e^-$ 4.14 GeV
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⁶ Expressed as a value, the BAI 90 result is $\Gamma(e^+ \text{anything})/\Gamma_{\text{total}} = 0.05 \pm 0.05 \pm 0.02$.

Γ_5/Γ

$\Gamma(\phi \text{anything})/\Gamma_{\text{total}}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
$0.178^{+0.151+0.006}_{-0.072-0.063}$	3	BAI	98 BES	$e^+ e^- \rightarrow D_s^+ D_s^-$

Γ_6/Γ

———— Leptonic and semileptonic modes ———

$\Gamma(\mu^+ \nu_\mu)/\Gamma_{\text{total}}$

Γ_7/Γ

See the "Note on Pseudoscalar-Meson Decay Constants" in the Listings for the π^\pm .

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$0.015^{+0.013}_{-0.006} {}^{+0.003}_{-0.002}$	3	7 BAI	95 BES	$e^+ e^- \rightarrow D_s^+ D_s^-$
$0.004^{+0.0018}_{-0.0014} {}^{+0.0020}_{-0.0019}$	8	8 AOKI	93 WA75	π^- emulsion 350 GeV
<0.03	0	9 AUBERT	83 SPEC	$\mu^+ \text{Fe}$, 250 GeV

⁷ BAI 95 uses one actual $D_s^+ \rightarrow \mu^+ \nu_\mu$ event together with two $D_s^+ \rightarrow \tau^+ \nu_\tau$ events and assumes $\mu\tau$ universality. This value of $\Gamma(\mu^+ \nu_\mu)/\Gamma_{\text{total}}$ gives a pseudoscalar decay constant of $(430^{+150}_{-130} \pm 40)$ MeV.

⁸ AOKI 93 assumes the ratio of production cross sections of the D_s^+ and D_s^0 is 0.27. The value of $\Gamma(\mu^+ \nu_\mu)/\Gamma_{\text{total}}$ gives a pseudoscalar decay constant $f_{D_s} = (232 \pm 45 \pm 52)$ MeV.

⁹ AUBERT 83 assume that the D_s^\pm production rate is 20% of total charm production rate.

$\Gamma(\mu^+ \nu_\mu)/\Gamma(\phi\pi^+)$

Γ_7/Γ_{15}

See the "Note on Pseudoscalar-Meson Decay Constants" in the Listings for the π^\pm .

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.13 ± 0.04 OUR NEW UNCHECKED FIT				Error includes scale factor of 1.5. [0.11 ± 0.05 OUR 1998 FIT Scale factor = 1.6]

0.17 ± 0.04 OUR NEW AVERAGE [0.24 ± 0.09 OUR 1998 AVERAGE]

0.173 ± 0.023 ± 0.035 182 10 CHADA 98 CLE2 $e^+ e^- \approx \gamma(4S)$

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.245 ± 0.052 ± 0.074 39 11 ACOSTA 94 CLE2 See CHADA 98

10 CHADA 98 obtains $f_{D_s} = (280 \pm 19 \pm 28 \pm 34)$ MeV from this measurement, using
 $\Gamma(D_s^+ \rightarrow \phi\pi^+)/\Gamma(\text{total}) = 0.036 \pm 0.009$.

11 ACOSTA 94 obtains $f_{D_s} = (344 \pm 37 \pm 52 \pm 42)$ MeV from this measurement, using
 $\Gamma(D_s^+ \rightarrow \phi\pi^+)/\Gamma(\text{total}) = 0.037 \pm 0.009$.

$\Gamma(\mu^+ \nu_\mu)/\Gamma(\phi\ell^+ \nu_\ell)$

Γ_7/Γ_9

See the "Note on Pseudoscalar-Meson Decay Constants" in the Listings for the π^\pm .

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.23 ± 0.08 OUR NEW UNCHECKED FIT				Error includes scale factor of 1.5. [0.20 ± 0.10 OUR 1998 FIT Scale factor = 1.6]

0.16 ± 0.06 ± 0.03 23 12 KODAMA 96 E653 π^- emulsion, 600 GeV

12 KODAMA 96 obtains $f_{D_s} = (194 \pm 35 \pm 20 \pm 14)$ MeV from this measurement, using
 $\Gamma(D_s^+ \rightarrow \phi\ell^+ \nu_\ell)/\Gamma_{\text{total}} = 0.0188 \pm 0.0029$. The third error is from the uncertainty on
 $\phi\ell^+ \nu_\ell$ branching fraction.

$\Gamma(\tau^+ \nu_\tau)/\Gamma_{\text{total}}$

Γ_8/Γ

See the "Note on Pseudoscalar-Meson Decay Constants" in the Listings for the π^\pm .

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.074 ± 0.028 ± 0.024	16	13 ACCIARRI	97F L3	$D_s^{*+} \rightarrow \gamma D_s^+$

13 The second ACCIARRI 97F error here combines in quadrature systematic (0.016) and normalization (0.018) errors. The branching fraction gives $f_{D_s} = (309 \pm 58 \pm 33 \pm 38)$ MeV.

$\Gamma(\phi\ell^+ \nu_\ell)/\Gamma(\phi\pi^+)$

Γ_9/Γ_{15}

For now, we average together measurements of the $\Gamma(\phi e^+ \nu_e)/\Gamma(\phi\pi^+)$ and $\Gamma(\phi\mu^+ \nu_\mu)/\Gamma(\phi\pi^+)$ ratios. See the end of the D_s^+ Listings for measurements of $D_s^+ \rightarrow \phi\ell^+ \nu_\ell$ form-factor ratios.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.56 ± 0.05 OUR NEW UNCHECKED FIT				[0.55 ± 0.05 OUR 1998 FIT]

0.54 ± 0.05 OUR AVERAGE

0.54 ± 0.05 ± 0.04	367	14 BUTLER	94 CLE2	$e^+ e^- \approx \gamma(4S)$
0.58 ± 0.17 ± 0.07	97	15 FRABETTI	93G E687	$\gamma\text{Be} \bar{E}_\gamma = 220$ GeV
0.57 ± 0.15 ± 0.15	104	16 ALBRECHT	91 ARG	$e^+ e^- \approx 10.4$ GeV
0.49 ± 0.10 ± 0.14	54	17 ALEXANDER	90B CLEO	$e^+ e^-$ 10.5–11 GeV

14 BUTLER 94 uses both $\phi e^+ \nu_e$ and $\phi\mu^+ \nu_\mu$ events, and makes a phase-space adjustment to the latter to use them as $\phi e^+ \nu_e$ events.

¹⁵ FRABETTI 93G measures the $\Gamma(\phi\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ ratio.

¹⁶ ALBRECHT 91 measures the $\Gamma(\phi e^+\nu_e)/\Gamma(\phi\pi^+)$ ratio.

¹⁷ ALEXANDER 90B measures an average of the $\Gamma(\phi e^+\nu_e)/\Gamma(\phi\pi^+)$ and $\Gamma(\phi\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ ratios.

$\Gamma(\eta\ell^+\nu_\ell)/\Gamma(\phi\ell^+\nu_\ell)$

Γ_{11}/Γ_9

Unseen decay modes of the η and the ϕ are included.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
1.27±0.19 OUR FIT				

1.24±0.12±0.15 440 ¹⁸ BRANDENB... 95 CLE2 $e^+e^- \approx \gamma(4S)$

¹⁸ BRANDENBURG 95 uses both e^+ and μ^+ events and makes a phase-space adjustment to use the μ^+ events as e^+ events.

$\Gamma(\eta'(958)\ell^+\nu_\ell)/\Gamma(\phi\ell^+\nu_\ell)$

Γ_{12}/Γ_9

Unseen decay modes of the resonances are included.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.44±0.13 OUR FIT					

0.43±0.11±0.07 29 ¹⁹ BRANDENB... 95 CLE2 $e^+e^- \approx \gamma(4S)$

• • • We do not use the following data for averages, fits, limits, etc. • • •

<1.6 90 ²⁰ KODAMA 93B E653 π^- emulsion 600 GeV

¹⁹ BRANDENBURG 95 uses both e^+ and μ^+ events and makes a phase-space adjustment to use the μ^+ events as e^+ events.

²⁰ KODAMA 93B uses μ^+ events.

$[\Gamma(\eta\ell^+\nu_\ell) + \Gamma(\eta'(958)\ell^+\nu_\ell)]/\Gamma(\phi\ell^+\nu_\ell)$

$\Gamma_{10}/\Gamma_9 = (\Gamma_{11} + \Gamma_{12})/\Gamma_9$

Unseen decay modes of the resonances are included.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
1.72±0.23 OUR FIT				

3.9 ±1.6 13 ²¹ KODAMA 93 E653 π^- emulsion 600 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

1.67±0.17±0.17 ²² BRANDENB... 95 CLE2 $e^+e^- \approx \gamma(4S)$

²¹ KODAMA 93 uses μ^+ events.

²² This BRANDENBURG 95 data is redundant with data in previous blocks.

———— Hadronic modes with a $K\bar{K}$ pair. ———

$\Gamma(K^+\bar{K}^0)/\Gamma(\phi\pi^+)$

Γ_{13}/Γ_{15}

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
1.01±0.16 OUR AVERAGE				
1.15±0.31±0.19	68	ANJOS	90C E691	γ Be
0.92±0.32±0.20		ADLER	89B MRK3	e^+e^- 4.14 GeV
0.99±0.17±0.10		CHEN	89 CLEO	e^+e^- 10 GeV

$\Gamma(\phi\pi^+)/\Gamma_{\text{total}}$ Γ_{15}/Γ

We now have model-independent measurements of this branching fraction, and so we no longer use the earlier, model-dependent results.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.036 ± 0.009 OUR FIT					
0.036 ± 0.009 OUR AVERAGE					
0.0359 ± 0.0077 ± 0.0048		23 ARTUSO	96 CLE2	$e^+ e^-$ at $\gamma(4S)$	
0.039 +0.051 +0.018 -0.019 -0.011		24 BAI	95C BES	$e^+ e^-$ 4.03 GeV	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.051 ± 0.004 ± 0.008		25 BUTLER	94 CLE2	$e^+ e^- \approx \gamma(4S)$	
<0.048	90	MUHEIM	94		
0.046 ± 0.015		26 MUHEIM	94		
0.031 ± 0.009		26 MUHEIM	94		
0.031 ± 0.009 ± 0.006		25 FRABETTI	93G E687	$\gamma Be \bar{E}_\gamma = 220$ GeV	
0.024 ± 0.010		25 ALBRECHT	91 ARG	$e^+ e^- \approx 10.4$ GeV	
<0.041	90	0	24 ADLER	90B MRK3	$e^+ e^-$ 4.14 GeV
0.031 ± 0.006 +0.011 -0.009		25 ALEXANDER	90B CLEO	$e^+ e^-$ 10.5–11 GeV	
0.048 ± 0.017 ± 0.019		27 ALVAREZ	90C NA14	Photoproduction	
>0.034	90	25 ANJOS	90B E691	$\gamma Be, \bar{E}_\gamma \approx 145$ GeV	
0.02 ± 0.01	405	28 CHEN	89 CLEO	$e^+ e^-$ 10 GeV	
0.033 ± 0.016 ± 0.010	9	28 BRAUNSCH...	87 TASS	$e^+ e^-$ 35–44 GeV	
0.033 ± 0.011	30	28 DERRICK	85B HRS	$e^+ e^-$ 29 GeV	

23 ARTUSO 96 uses partially reconstructed $\bar{B}^0 \rightarrow D_s^{*+} D_s^{*-}$ decays to get a model-independent value for $\Gamma(D_s^- \rightarrow \phi\pi^-)/\Gamma(D^0 \rightarrow K^-\pi^+)$ of $0.92 \pm 0.20 \pm 0.11$.

24 BAI 95C uses $e^+ e^- \rightarrow D_s^+ D_s^-$ events in which one or both of the D_s^\pm are observed to obtain the first model-independent measurement of the $D_s^+ \rightarrow \phi\pi^+$ branching fraction, without assumptions about $\sigma(D_s^\pm)$. However, with only two “doubly-tagged” events, the statistical error is too large for the result to be competitive with indirect measurements. ADLER 90B used the same method to set a limit.

25 BUTLER 94, FRABETTI 93G, ALBRECHT 91, ALEXANDER 90B, and ANJOS 90B measure the ratio $\Gamma(D_s^+ \rightarrow \phi\ell^+\nu_\ell)/\Gamma(D_s^+ \rightarrow \phi\pi^+)$, where $\ell = e$ and/or μ , and then use a theoretical calculation of the ratio of widths $\Gamma(D_s^+ \rightarrow \phi\ell^+\nu_\ell)/\Gamma(D^+ \rightarrow \bar{K}^{*0}\ell^+\nu)$. Not everyone uses the same value for this ratio.

26 The two MUHEIM 94 values here are model-dependent calculations based on distinct data sets. The first uses measurements of the $D_2^*(2460)^0$ and $D_{s1}(2536)^+$, the second uses B -decay factorization and $\Gamma(D_s^+ \rightarrow \mu^+\nu_\mu)/\Gamma(D_s^+ \rightarrow \phi\ell^+\nu_\ell)$. A third calculation using the semileptonic width of $D_s^+ \rightarrow \phi\ell^+\nu_\ell$ is not independent of other results listed here. Note also the upper limit, based on the sum of established D_s^+ branching ratios.

27 ALVAREZ 90C relies on the Lund model to estimate the ratio of D_s^+ to D^+ cross sections.

28 Values based on crude estimates of the D_s^\pm production level. DERRICK 85B errors are statistical only.

$\Gamma(\phi\pi^+)/\Gamma(K^+K^-\pi^+)$

Unseen decay modes of the ϕ are included.

VALUE	DOCUMENT ID	TECN	COMMENT
0.82 ± 0.08 OUR FIT			
0.807 ± 0.067 ± 0.096	FRABETTI	95B E687	Dalitz plot analysis

Γ_{15}/Γ_{14}

$\Gamma(K^+\bar{K}^*(892)^0)/\Gamma(K^+K^-\pi^+)$

Unseen decay modes of the $\bar{K}^*(892)^0$ are included.

VALUE	DOCUMENT ID	TECN	COMMENT
0.75 ± 0.07 OUR FIT			
0.717 ± 0.069 ± 0.060	FRABETTI	95B E687	Dalitz plot analysis

Γ_{16}/Γ_{14}

$\Gamma(K^+\bar{K}^*(892)^0)/\Gamma(\phi\pi^+)$

Unseen decay modes of the resonances are included.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.92 ± 0.09 OUR FIT				
0.95 ± 0.10 OUR AVERAGE				
0.85 ± 0.34 ± 0.20	9	ALVAREZ	90C NA14	Photoproduction
0.84 ± 0.30 ± 0.22		ADLER	89B MRK3	e^+e^- 4.14 GeV
1.05 ± 0.17 ± 0.12		CHEN	89 CLEO	e^+e^- 10 GeV
0.87 ± 0.13 ± 0.05	117	ANJOS	88 E691	Photoproduction
1.44 ± 0.37	87	ALBRECHT	87F ARG	e^+e^- 10 GeV

Γ_{16}/Γ_{15}

$\Gamma(f_0(980)\pi^+)/\Gamma(K^+K^-\pi^+)$

Unseen decay modes of the $f_0(980)$ are included.

VALUE	DOCUMENT ID	TECN	COMMENT
0.40 ± 0.16 OUR FIT	Error includes scale factor of 2.3.		
1.00 ± 0.32 ± 0.24	FRABETTI	95B E687	Dalitz plot analysis

Γ_{37}/Γ_{14}

$\Gamma(f_0(1710)\pi^+ \rightarrow K^+K^-\pi^+)/\Gamma(K^+K^-\pi^+)$

This includes *only* K^+K^- decays of the $f_0(1710)$, because branching fractions of this resonance are not known.

VALUE	DOCUMENT ID	TECN	COMMENT
0.034 ± 0.023 ± 0.035	FRABETTI	95B E687	Dalitz plot analysis

Γ_{19}/Γ_{14}

$\Gamma(K^+\bar{K}_0^*(1430)^0)/\Gamma(K^+K^-\pi^+)$

Unseen decay modes of the $\bar{K}_0^*(1430)^0$ are included.

VALUE	DOCUMENT ID	TECN	COMMENT
0.150 ± 0.052 ± 0.052	FRABETTI	95B E687	Dalitz plot analysis

Γ_{18}/Γ_{14}

$\Gamma(K^+K^-\pi^+ \text{ nonresonant})/\Gamma(\phi\pi^+)$

Γ_{20}/Γ_{15}

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.25 ± 0.07 ± 0.05	48	ANJOS	88 E691	Photoproduction

$\Gamma(K^*(892)^+ \bar{K}^0)/\Gamma(\phi\pi^+)$

Γ_{22}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	DOCUMENT ID	TECN	COMMENT
1.20 ± 0.21 ± 0.13	CHEN	89 CLEO	e^+e^- 10 GeV

$\Gamma(K^*(892)^+ \bar{K}^0)/\Gamma(K^+ \bar{K}^0)$

Γ_{22}/Γ_{13}

Unseen decay modes of the $K^*(892)^+$ are included.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.9	90	FRABETTI	95 E687	γ Be $\bar{E}_\gamma \approx 200$ GeV

$\Gamma(\phi \pi^+ \pi^0)/\Gamma(\phi \pi^+)$

Γ_{24}/Γ_{15}

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
2.4 ± 1.0 ± 0.5	11		ANJOS	89E E691	Photoproduction
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<2.6	90		ALVAREZ	90C NA14	Photoproduction

$\Gamma(\phi \rho^+)/\Gamma(\phi \pi^+)$

Γ_{25}/Γ_{15}

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
1.86 ± 0.26 ± 0.29	253	AVERY	92 CLE2	$e^+ e^- \simeq 10.5$ GeV

$\Gamma(\phi \pi^+ \pi^0 \text{3-body})/\Gamma(\phi \pi^+)$

Γ_{26}/Γ_{15}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.71	90	DAOUDI	92 CLE2	$e^+ e^- \approx 10.5$ GeV

$\Gamma(K^+ K^- \pi^+ \pi^0 \text{non-}\phi)/\Gamma(\phi \pi^+)$

Γ_{27}/Γ_{15}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<2.4	90	29 ANJOS	89E E691	Photoproduction

²⁹ Total minus ϕ component.

$\Gamma(K^+ \bar{K}^0 \pi^+ \pi^-)/\Gamma(\phi \pi^+)$

Γ_{28}/Γ_{15}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.77	90	ALBRECHT	92B ARG	$e^+ e^- \simeq 10.4$ GeV

$\Gamma(K^0 K^- \pi^+ \pi^+)/\Gamma(\phi \pi^+)$

Γ_{29}/Γ_{15}

VALUE	DOCUMENT ID	TECN	COMMENT
1.2 ± 0.2 ± 0.2	ALBRECHT	92B ARG	$e^+ e^- \simeq 10.4$ GeV

$\Gamma(K^*(892)^+ \bar{K}^*(892)^0)/\Gamma(\phi \pi^+)$

Γ_{30}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	DOCUMENT ID	TECN	COMMENT
1.6 ± 0.4 ± 0.4	ALBRECHT	92B ARG	$e^+ e^- \simeq 10.4$ GeV

$\Gamma(K^0 K^- \pi^+ \pi^+ \text{non-}K^*+\bar{K}^{*0})/\Gamma(\phi \pi^+)$

Γ_{31}/Γ_{15}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.80	90	ALBRECHT	92B ARG	$e^+ e^- \simeq 10.4$ GeV

$\Gamma(K^+ K^- \pi^+ \pi^+ \pi^-)/\Gamma(K^+ K^- \pi^+)$

Γ_{32}/Γ_{14}

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.188 ± 0.036 ± 0.040	75	FRABETTI	97C E687	γ Be, $\bar{E}_\gamma \approx 200$ GeV

$\Gamma(\phi\pi^+\pi^+\pi^-)/\Gamma(\phi\pi^+)$

Γ_{33}/Γ_{15}

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.33±0.06 OUR AVERAGE					
0.28±0.06±0.01		40	FRABETTI	97C E687	γ Be, $\bar{E}_\gamma \approx 200$ GeV
0.58±0.21±0.10		21	FRABETTI	92 E687	γ Be
0.42±0.13±0.07		19	ANJOS	88 E691	Photoproduction
1.11±0.37±0.28		62	ALBRECHT	85D ARG	$e^+e^- 10$ GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.24		90	ALVAREZ	90C NA14	Photoproduction

$\Gamma(K^+K^-\pi^+\pi^+\pi^- \text{non-}\phi)/\Gamma_{\text{total}}$

Γ_{34}/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.003 $^{+0.003}_{-0.002}$	BARLAG	92C ACCM	$\pi^- 230$ GeV

$\Gamma(K^+K^-\pi^+\pi^+\pi^- \text{non-}\phi)/\Gamma(\phi\pi^+)$

Γ_{34}/Γ_{15}

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.32	90	10	ANJOS	88 E691	Photoproduction

— Hadronic modes without K's —

$\Gamma(\pi^+\pi^+\pi^-)/\Gamma(K^+K^-\pi^+)$

Γ_{35}/Γ_{14}

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.23 ± 0.04 OUR FIT				Error includes scale factor of 1.2.
0.265 $\pm 0.041 \pm 0.031$	98	FRABETTI	97D E687	γ Be ≈ 200 GeV

$\Gamma(\pi^+\pi^+\pi^-)/\Gamma(\phi\pi^+)$

Γ_{35}/Γ_{15}

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.28 ± 0.06 OUR FIT				Error includes scale factor of 1.3.
0.39 ± 0.08 OUR AVERAGE				

$\Gamma(\rho^0\pi^+)/\Gamma(\pi^+\pi^+\pi^-)$

Γ_{36}/Γ_{35}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.073	90	FRABETTI	97D E687	γ Be ≈ 200 GeV

$\Gamma(\rho^0\pi^+)/\Gamma(\phi\pi^+)$

Γ_{36}/Γ_{15}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.08	90	ANJOS	89 E691	Photoproduction
<0.22	90	ALBRECHT	87G ARG	$e^+e^- 10$ GeV

$\Gamma(f_0(980)\pi^+)/\Gamma(\pi^+\pi^+\pi^-)$

Γ_{37}/Γ_{35}

VALUE	DOCUMENT ID	TECN	COMMENT
1.7 ± 0.6 OUR FIT			Error includes scale factor of 2.4.
2.06 $\pm 0.27 \pm 0.08$	FRABETTI	97D E687	γ Be ≈ 200 GeV

$\Gamma(f_0(980)\pi^+)/\Gamma(\phi\pi^+)$

Γ_{37}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	DOCUMENT ID	TECN	COMMENT
0.49±0.20 OUR FIT			Error includes scale factor of 2.6.
0.28±0.10±0.03	ANJOS	89	Photoproduction

$\Gamma(f_2(1270)\pi^+)/\Gamma(\pi^+\pi^+\pi^-)$

Γ_{38}/Γ_{35}

Unseen decay modes of the $f_2(1270)$ are included.

VALUE	DOCUMENT ID	TECN	COMMENT
0.22±0.10±0.03	FRABETTI	97D	γ Be \approx 200 GeV

$\Gamma(f_0(1500)\pi^+ \rightarrow \pi^+\pi^-\pi^+)/\Gamma(\pi^+\pi^+\pi^-)$

Γ_{39}/Γ_{35}

This includes only $\pi^+\pi^-$ decays of the $f_0(1500)$, because branching fractions of this resonance are not known.

VALUE	DOCUMENT ID	TECN	COMMENT
0.274±0.114±0.019	30 FRABETTI	97D	γ Be \approx 200 GeV

30 FRABETTI 97D calls this mode $S(1475)\pi^+$, but finds the mass and width of this $S(1475)$ to be in excellent agreement with those of the $f_0(1500)$.

$\Gamma(\pi^+\pi^+\pi^- \text{ nonresonant})/\Gamma(\pi^+\pi^+\pi^-)$

Γ_{40}/Γ_{35}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.269	90	31 FRABETTI	97D	γ Be \approx 200 GeV

31 We rather arbitrarily use this FRABETTI 97D limit instead of the much large ANJOS 89 value given in the next entry. See, however, FRABETTI 97D on the difficulty of distinguishing the $f_0(1500)\pi^+$ and nonresonant modes.

$\Gamma(\pi^+\pi^+\pi^- \text{ nonresonant})/\Gamma(\phi\pi^+)$

Γ_{40}/Γ_{15}

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.29±0.09±0.03	ANJOS	89	Photoproduction

$\Gamma(\pi^+\pi^+\pi^-\pi^0)/\Gamma(\phi\pi^+)$

Γ_{41}/Γ_{15}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<3.3	90	ANJOS	89E	Photoproduction

$\Gamma(\eta\pi^+)/\Gamma(\phi\pi^+)$

Γ_{42}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.48±0.05 OUR NEW AVERAGE			[0.54 ± 0.11 OUR 1998 AVERAGE]		
0.48±0.03±0.04	920	JESSOP	98	CLE2	$e^+e^- \approx \gamma(4S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.54±0.09±0.06	165	ALEXANDER	92	CLE2	See JESSOP 98
<1.5	90	ANJOS	89E	E691	Photoproduction

$\Gamma(\omega\pi^+)/\Gamma(\phi\pi^+)$

Γ_{43}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.5	90	ANJOS	89E	E691 Photoproduction

$\Gamma(\omega\pi^+)/\Gamma(\eta\pi^+)$

VALUE	DOCUMENT ID	TECN	COMMENT	Γ_{43}/Γ_{42}
0.16±0.04±0.03	BALEST	97	CLE2 $e^+e^- \approx \gamma(4S)$	

$\Gamma(\pi^+\pi^+\pi^+\pi^-\pi^-)/\Gamma(K^+K^-\pi^+)$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	Γ_{44}/Γ_{14}
0.158±0.042±0.031	37	FRABETTI	97C E687	$\gamma Be, \bar{E}_\gamma \approx 200$ GeV	

$\Gamma(\pi^+\pi^+\pi^+\pi^-\pi^-)/\Gamma(\phi\pi^+)$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT	Γ_{44}/Γ_{15}
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.29	90	ANJOS	89	E691 Photoproduction	

$\Gamma(\eta\rho^+)/\Gamma(\phi\pi^+)$

Unseen decay modes of the resonances are included.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	Γ_{46}/Γ_{15}
3.0 ± 0.4 OUR NEW AVERAGE		[2.9 ± 0.5 OUR 1998 AVERAGE]			
2.98±0.20±0.39	447	JESSOP	98	CLE2 $e^+e^- \approx \gamma(4S)$	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.86±0.38 ^{+0.36} _{-0.38}	217	AVERY	92	CLE2 See JESSOP 98	

$\Gamma(\eta\pi^+\pi^0\text{3-body})/\Gamma(\phi\pi^+)$

Unseen decay modes of the resonances are included.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT	Γ_{47}/Γ_{15}
<1.1 (CL = 90%)	[<0.82 (CL = 90%) OUR 1998 BEST LIMIT]				
<1.1	90	JESSOP	98	CLE2 $e^+e^- \approx \gamma(4S)$	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.82	90	³² DAOUDI	92	CLE2 See JESSOP 98	

³² We use the JESSOP 98 limit, even though the DAOUDI 92 limit, from the same experiment but with a much smaller data sample, is more restrictive.

$\Gamma(\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0)/\Gamma_{\text{total}}$

VALUE	DOCUMENT ID	TECN	COMMENT	Γ_{48}/Γ
0.049^{+0.033}_{-0.030}	BARLAG	92C ACCM	π^- 230 GeV	

$\Gamma(\eta'(958)\pi^+)/\Gamma(\phi\pi^+)$

Unseen decay modes of the resonances are included.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT	Γ_{49}/Γ_{15}
1.08±0.09 OUR NEW AVERAGE			[1.4 ± 0.4 OUR 1998 AVERAGE Scale factor = 2.1]			
1.03±0.06±0.07	537	JESSOP	98	CLE2 $e^+e^- \approx \gamma(4S)$		
2.5 ± 1.0 ^{+1.5} _{-0.4}	22	ALVAREZ	91	NA14 Photoproduction		
2.5 ± 0.5 ± 0.3	215	ALBRECHT	90D ARG	$e^+e^- \approx 10.4$ GeV		
• • • We do not use the following data for averages, fits, limits, etc. • • •						
1.20±0.15±0.11	281	ALEXANDER	92	CLE2 See JESSOP 98		
<1.3	90	ANJOS	91B E691	$\gamma Be, \bar{E}_\gamma \approx 145$ GeV		

$\Gamma(\eta'(958)\rho^+)/\Gamma(\phi\pi^+)$

Γ_{51}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
2.8 ± 0.4 OUR NEW AVERAGE		[3.4 ± 0.8 OUR 1998 AVERAGE]		
2.78±0.28±0.30	137	JESSOP	98	CLE2 $e^+e^- \approx \gamma(4S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$3.44 \pm 0.62^{+0.44}_{-0.46}$	68	AVERY	92	CLE2 See JESSOP 98

$\Gamma(\eta'(958)\pi^+\pi^0\text{3-body})/\Gamma(\phi\pi^+)$

Γ_{52}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.4 (CL = 90%)	[<0.85 (CL = 90%) OUR 1998 BEST LIMIT]			
<0.4	90	JESSOP	98	CLE2 $e^+e^- \approx \gamma(4S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.85	90	DAOUDI	92	CLE2 See JESSOP 98

— Modes with one or three K's —

$\Gamma(K^0\pi^+)/\Gamma(\phi\pi^+)$

Γ_{53}/Γ_{15}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.21	90	ADLER	89B	MRK3 $e^+e^- 4.14 \text{ GeV}$

$\Gamma(K^0\pi^+)/\Gamma(K^+\bar{K}^0)$

Γ_{53}/Γ_{13}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.53	90	FRABETTI	95	E687 $\gamma\text{Be } \bar{E}_\gamma \approx 200 \text{ GeV}$

$\Gamma(K^+\pi^+\pi^-)/\Gamma(\phi\pi^+)$

Γ_{54}/Γ_{15}

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.28±0.06±0.05	85	FRABETTI	95E	E687 $\gamma\text{Be}, \bar{E}_\gamma = 220 \text{ GeV}$

$\Gamma(K^+\rho^0)/\Gamma(\phi\pi^+)$

Γ_{55}/Γ_{15}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.08	90	FRABETTI	95E	E687 $\gamma\text{Be}, \bar{E}_\gamma = 220 \text{ GeV}$

$\Gamma(K^*(892)^0\pi^+)/\Gamma(\phi\pi^+)$

Γ_{56}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.18±0.05±0.04	25	FRABETTI	95E	E687 $\gamma\text{Be}, \bar{E}_\gamma = 220 \text{ GeV}$

$\Gamma(K^+K^+K^-)/\Gamma(\phi\pi^+)$

Γ_{57}/Γ_{15}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.016	90	FRABETTI	95F	E687 $\gamma\text{Be}, \bar{E}_\gamma \approx 220 \text{ GeV}$

$\Gamma(\phi K^+)/\Gamma(\phi\pi^+)$

Γ_{58}/Γ_{15}

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.013	90	FRABETTI	95F	E687 $\gamma\text{Be}, \bar{E}_\gamma \approx 220 \text{ GeV}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.071	90	ANJOS	92D	E691 $\gamma\text{Be}, \bar{E}_\gamma = 145 \text{ GeV}$

Rare or forbidden modes $\Gamma(\pi^+ e^+ e^-)/\Gamma_{\text{total}}$ Γ_{59}/Γ

This mode is not a useful test for a $\Delta C=1$ weak neutral current because both quarks must change flavor in this decay.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<2.7 \times 10^{-4}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV

 $\Gamma(\pi^+ \mu^+ \mu^-)/\Gamma_{\text{total}}$ Γ_{60}/Γ

This mode is not a useful test for a $\Delta C=1$ weak neutral current because both quarks must change flavor in this decay.

<u>VALUE</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<1.4 \times 10^{-4}$ (CL = 90%)			[$<4.3 \times 10^{-4}$ (CL = 90%) OUR 1998 BEST LIMIT]		
$<1.4 \times 10^{-4}$	90		AITALA	99G E791	$\pi^- N$ 500 GeV
• • •	We do not use the following data for averages, fits, limits, etc. • • •				

$<4.3 \times 10^{-4}$ 90 0 KODAMA 95 E653 π^- emulsion 600 GeV

 $\Gamma(K^+ e^+ e^-)/\Gamma_{\text{total}}$ Γ_{61}/Γ

A test for the $\Delta C=1$ weak neutral current. Allowed by higher-order electroweak interactions.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<1.6 \times 10^{-3}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV

 $\Gamma(K^+ \mu^+ \mu^-)/\Gamma_{\text{total}}$ Γ_{62}/Γ

A test for the $\Delta C=1$ weak neutral current. Allowed by higher-order electroweak interactions.

<u>VALUE</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<1.4 \times 10^{-4}$ (CL = 90%)			[$<5.9 \times 10^{-4}$ (CL = 90%) OUR 1998 BEST LIMIT]		
$<1.4 \times 10^{-4}$	90		AITALA	99G E791	$\pi^- N$ 500 GeV
• • •	We do not use the following data for averages, fits, limits, etc. • • •				

$<5.9 \times 10^{-4}$ 90 0 KODAMA 95 E653 π^- emulsion 600 GeV

 $\Gamma(K^*(892)^+ \mu^+ \mu^-)/\Gamma_{\text{total}}$ Γ_{63}/Γ

A test for the $\Delta C=1$ weak neutral current. Allowed by higher-order electroweak interactions.

<u>VALUE</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<1.4 \times 10^{-3}$	90	0	KODAMA	95 E653	π^- emulsion 600 GeV

 $\Gamma(\pi^\pm e^\pm \mu^\mp)/\Gamma_{\text{total}}$ Γ_{64}/Γ

A test of lepton-family-number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<6.1 \times 10^{-4}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV

 $\Gamma(K^\pm e^\pm \mu^\mp)/\Gamma_{\text{total}}$ Γ_{65}/Γ

A test of lepton-family-number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<6.3 \times 10^{-4}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV

 $\Gamma(\pi^- e^+ e^+)/\Gamma_{\text{total}}$ Γ_{66}/Γ

A test of lepton-number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<6.9 \times 10^{-4}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV

$\Gamma(\pi^- \mu^+ \mu^+)/\Gamma_{\text{total}}$

A test of lepton-number conservation.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT		
$<8.2 \times 10^{-5}$ (CL = 90%)			[$<4.3 \times 10^{-4}$ (CL = 90%) OUR 1998 BEST LIMIT]				
$<8.2 \times 10^{-5}$	90		AITALA	99G E791	$\pi^- N$ 500 GeV		
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$							
$<4.3 \times 10^{-4}$	90	0	KODAMA	95 E653	π^- emulsion 600 GeV		

Γ_{67}/Γ

$\Gamma(\pi^- e^+ \mu^+)/\Gamma_{\text{total}}$

A test of lepton-number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<7.3 \times 10^{-4}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV

Γ_{68}/Γ

$\Gamma(K^- e^+ e^+)/\Gamma_{\text{total}}$

A test of lepton-number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<6.3 \times 10^{-4}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV

Γ_{69}/Γ

$\Gamma(K^- \mu^+ \mu^+)/\Gamma_{\text{total}}$

A test of lepton-number conservation.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT		
$<1.8 \times 10^{-4}$ (CL = 90%)			[$<5.9 \times 10^{-4}$ (CL = 90%) OUR 1998 BEST LIMIT]				
$<1.8 \times 10^{-4}$	90		AITALA	99G E791	$\pi^- N$ 500 GeV		
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$							
$<5.9 \times 10^{-4}$	90	0	KODAMA	95 E653	π^- emulsion 600 GeV		

Γ_{70}/Γ

$\Gamma(K^- e^+ \mu^+)/\Gamma_{\text{total}}$

A test of lepton-number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<6.8 \times 10^{-4}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV

Γ_{71}/Γ

$\Gamma(K^*(892)^- \mu^+ \mu^+)/\Gamma_{\text{total}}$

A test of lepton-number conservation.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
$<1.4 \times 10^{-3}$	90	0	KODAMA	95 E653	π^- emulsion 600 GeV

Γ_{72}/Γ

$D_s^+ \rightarrow \phi \ell^+ \nu_\ell$ FORM FACTORS

$r_2 \equiv A_2(0)/A_1(0)$ in $D_s^+ \rightarrow \phi \ell^+ \nu_\ell$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
1.60 ± 0.24 OUR NEW AVERAGE		[1.6 ± 0.4 OUR 1998 AVERAGE]		
$1.57 \pm 0.25 \pm 0.19$	271	AITALA	99D E791	$\phi e^+ \nu_e, \phi \mu^+ \nu_\mu$
$1.4 \pm 0.5 \pm 0.3$	308	AVERY	94B CLE2	$\phi e^+ \nu_e$
$1.1 \pm 0.8 \pm 0.1$	90	FRABETTI	94F E687	$\phi \mu^+ \nu_\mu$
$2.1^{+0.6}_{-0.5} \pm 0.2$	19	KODAMA	95 E653	$\phi \mu^+ \nu_\mu$

$r_V \equiv V(0)/A_1(0)$ in $D_s^+ \rightarrow \phi \ell^+ \nu_\ell$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
1.92±0.32 OUR NEW AVERAGE	[1.5 ± 0.5 OUR 1998 AVERAGE]			
2.27±0.35±0.22	271	AITALA	99D E791	$\phi e^+ \nu_e, \phi \mu^+ \nu_\mu$
0.9 ± 0.6 ± 0.3	308	AVERY	94B CLE2	$\phi e^+ \nu_e$
1.8 ± 0.9 ± 0.2	90	FRABETTI	94F E687	$\phi \mu^+ \nu_\mu$
2.3 +1.1 -0.9 ± 0.4	19	KODAMA	93 E653	$\phi \mu^+ \nu_\mu$

 Γ_L/Γ_T in $D_s^+ \rightarrow \phi \ell^+ \nu_\ell$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.72±0.18 OUR AVERAGE				
1.0 ± 0.3 ± 0.2	308	AVERY	94B CLE2	$\phi e^+ \nu_e$
1.0 ± 0.5 ± 0.1	90	33 FRABETTI	94F E687	$\phi \mu^+ \nu_\mu$
0.54±0.21±0.10	19	33 KODAMA	93 E653	$\phi \mu^+ \nu_\mu$

33 FRABETTI 94F and KODAMA 93 evaluate Γ_L/Γ_T for a lepton mass of zero. D_s^\pm REFERENCES

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BONVICINI	99	PRL 82 4586	G. Bonvicini <i>et al.</i>	(CLEO Collab.)
BAI	98	PR D57 28	J.Z. Bai <i>et al.</i>	(BEPC BES Collab.)
CHADA	98	PR D58 032002	M. Chada <i>et al.</i>	(CLEO Collab.)
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ACCIARRI	97F	PL B396 327	M. Acciarri <i>et al.</i>	(L3 Collab.)
BAI	97	PR D56 3779	J.Z. Bai <i>et al.</i>	(BEPC BES Collab.)
BALEST	97	PRL 79 1436	R. Balest <i>et al.</i>	(CLEO Collab.)
FRABETTI	97C	PL B401 131	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
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FRABETTI	95	PL B346 199	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
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ADAMOVICH	93	PL B305 177	M.I. Adamovich <i>et al.</i>	(CERN WA82 Collab.)
AOKI	93	PTP 89 131	S. Aoki <i>et al.</i>	(CERN WA75 Collab.)
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FRABETTI	93G	PL B313 253	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
KODAMA	93	PL B309 483	K. Kodama <i>et al.</i>	(FNAL E653 Collab.)
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BARLAG	92C	ZPHY C55 383	S. Barlag <i>et al.</i>	(ACCMOR Collab.)
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CHEN	89	PL B226 192	W.Y. Chen <i>et al.</i>	(CLEO Collab.)
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